Magnitude and Timing of Extreme Continental Extension, Central Death Valley Region, California

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New geochronologic, stratigraphic, and sedimentologic data indicate extreme late Cenozoic extension across the central Death Valley region (fig. 9). $^{40}Ar/^{39}Ar$ geochronology of sanidine from tuffs intercalated with steeply tilted sediments along the eastern margin of the central Death Valley region, including sections near Chicago Pass and at Eagle Mountain, indicates deposition from approximately 15 to 11.7 Ma (fig. 10). Clasts of marble, orthoquartzite, fusilinid limestone, and leucogabbro are prominent at both locations. The only known source in the Death Valley region for this clast assemblage is in the southern Cottonwood Mountains, more than 100 km away on the western flank of the Death Valley region. U/Pb geochronology of baddeleyite confirms that leucogabbro clasts from both sections have the same igneous crystallization age (~180 Ma) as the leucogabbroic phase of the Hunter Mountain batholith, in the southern Cottonwood Mountains. The sediments include debris flows, flood deposits, and monolithic boulder beds of large leucogabbro clasts (>1 m), suggesting deposition in an alluvial fan setting. Sedimentary transport of these deposits is unlikely to have exceeded 20 km. Restoration of the Eagle Mountain and Chicago Valley

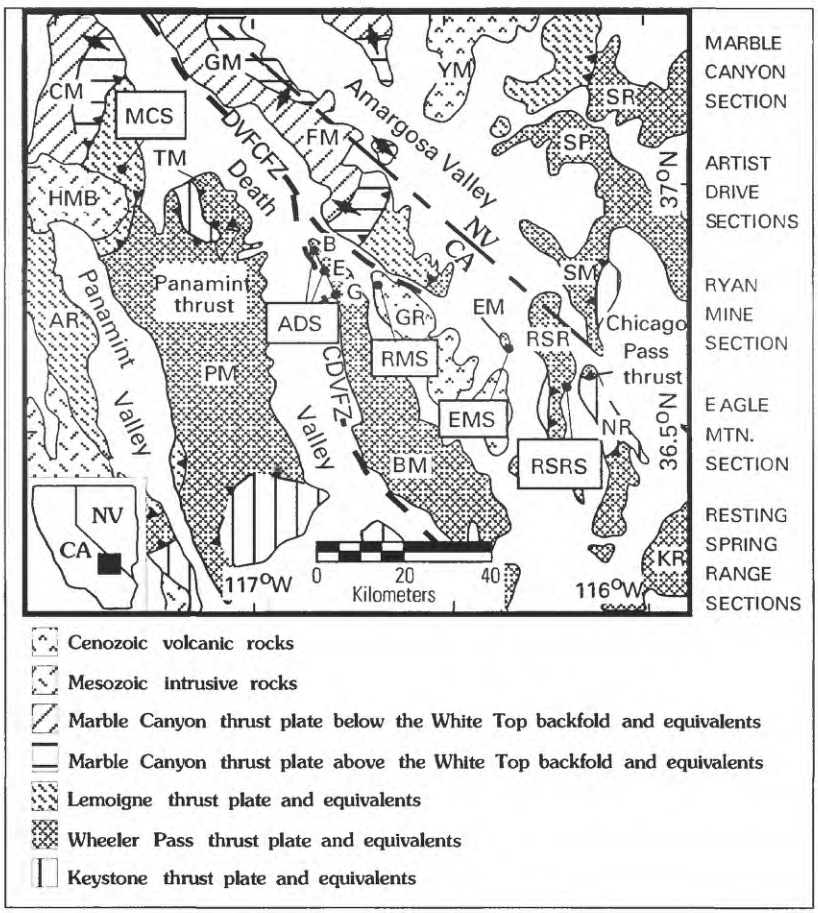


Figure 9. Map showing major ranges and basins in the Death Valley region, distribution of thrust faults and folds offset along Cenozoic normal and strike-slip faults, Hunter Mountain batholith, and locations of selected middle and upper Miocene stratigraphic sections discussed in text. Patterns on range blocks indicate thrust sheets as defined by Snow (1992). AR, Argus Range; BM, Black Mountains; CDVFZ, Central Death Valley Fault Zone; CM, Cottonwood Mountains; DVFCFZ, Death Valley–Furnace Creek Fault Zone; EM, Eagle Mountain; FM, Funeral Mountains; GM, Grapevine Mountains; GR, Greenwater Range; KR, Kingston Range; PM, Panamint Mountains; RSR, Resting Spring Range; SM, Spring Mountains; SP, Specter Range; SR, Spotted Range; TM, Tucki Mountain; YM, Yucca Mountain.

deposits to a position just east of the southern Cottonwood Mountains results in approximate net translations of 80 km and 104 km, respectively, at an azimuth of N. 67° W. (fig. 11). This suggests overall extension magnitudes of at least 500 percent across the Death Valley region since 12 Ma, with strain rates that approached 10^{-14}/s during maximum extension. These results support previous reconstructions based on isopachs and Mesozoic structural features. (See, for example, Wernicke and others, 1988.)

REFERENCES

Cemen, I., Wright, L.A., Drake, R.E., and Johnson, F.C., 1985, Cenozoic sedimentation and sequence of deformational events at the southeastern end of the Furnace Creek strike-slip fault zone, Death Valley region, California, *in* Biddle, K.T., and Christie-Blick, N., eds., Strike-slip deformation, basin formation, and sedimentation: Society of Economic Paleontologists and Mineralogists Special Publication 37, p. 127–141.

Greene, R.C., and Fleck, R.J., 1997, Geology of the northern Black Mountains, Death Valley, California: U.S. Geological Survey Open File Report 97-79, 110 p.

Snow, J.K.,1992, Large-magnitude Permian shortening and continental margin tectonics in the southern Cordillera: Geological Society of America Bulletin, v. 104, p. 80–105.

Snow, J.K., and Lux, D.R., in press, Tectono-sequence stratigraphy of Trtiary rocks in the Cottonwood Mountains and northern Death Valley area, California and Nevada, *in* Wright, L.A., ed., Cenozoic basins of the Death Valley region: Geological Society of America Special Paper 333.

Wernicke, B.P., Axen, G.J., and Snow, J.K., 1988, Basin and Range extensional tectonics at the latitude of Las Vegas, Nevada: Geological Society of America Bulletin, v. 100, p. 1738–1757.

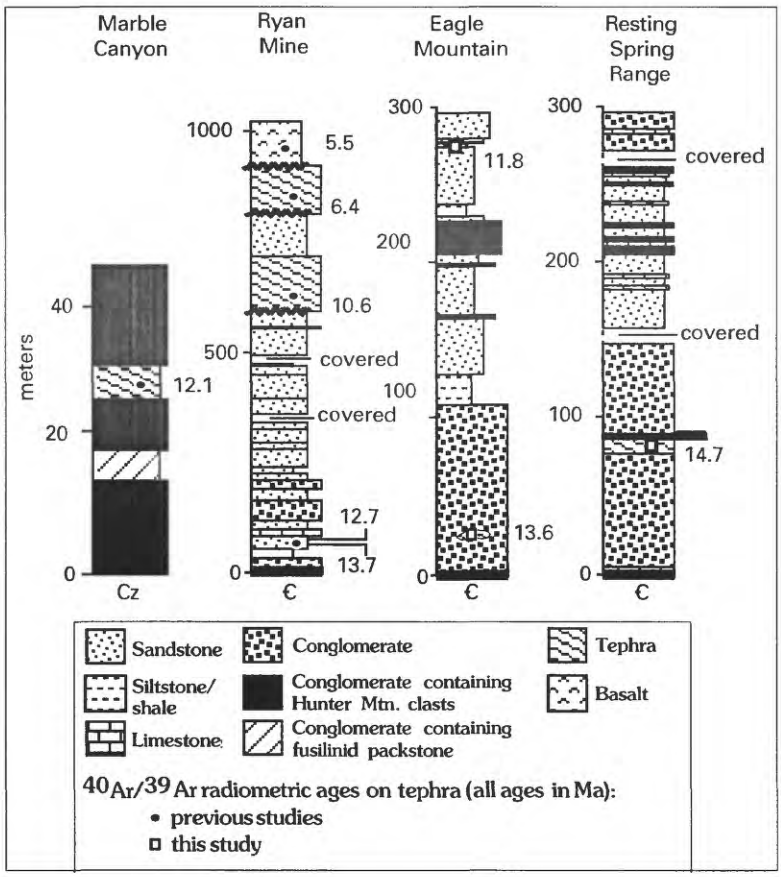
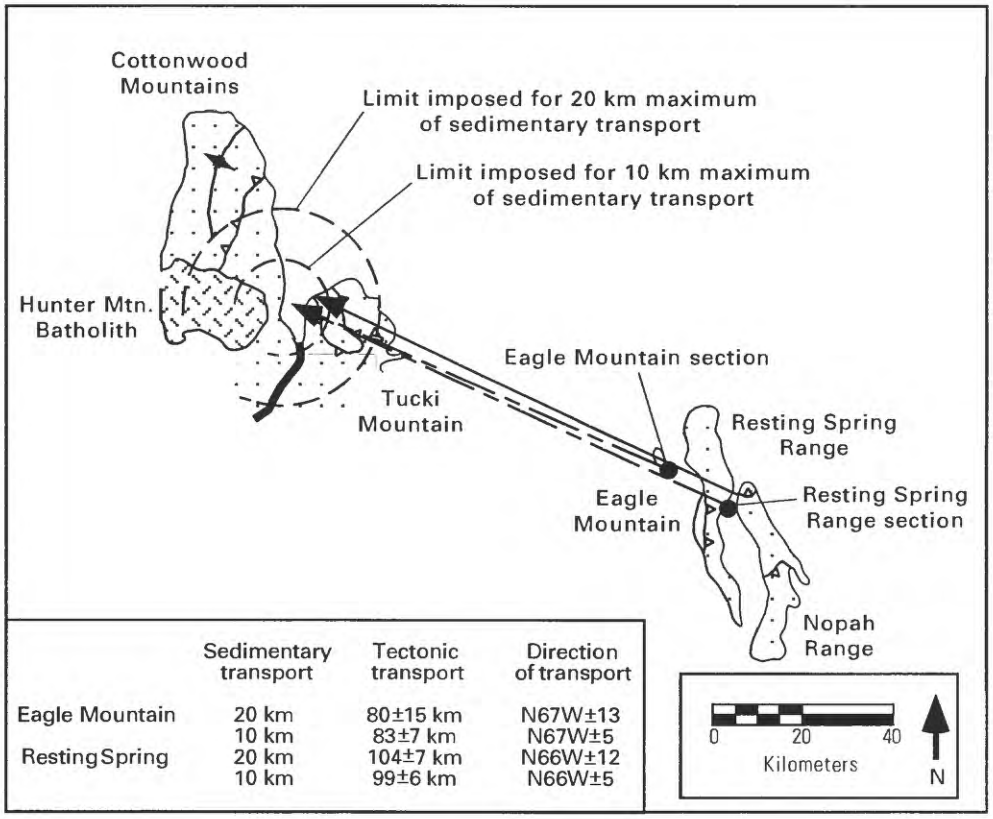


Figure 10. Columnar sections of middle and upper Miocene strata located on figure 9, except the Artist Drive sections. Marble Canyon section from Snow and Lux (in press). Ryan Mine section from Cemen and others (1985) and Greene and Fleck (1997). Radiometric ages for Ryan from Cemen and others (1985) and Greene and Fleck (1997), for Marble Canyon from Snow and Lux (in press) and this study. Note scale differences between sections.



	Sedimentary transport	Tectonic transport	Direction of transport
Eagle Mountain	20 km	80±15 km	N67W±13
	10 km	83±7 km	N67W±5
Resting Spring	20 km	104±7 km	N66W±12
	10 km	99±6 km	N66W±5

Figure 11. Map showing probable original limits of the Eagle Mountain Formation with respect to the southern Cottonwood Mountains for 10-km and 20-km maximum sedimentary transport from easternmost exposures of Hunter Mountain batholith.

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